Variables affecting the psychophysical function for taste

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ABSTRACT

Methodological studies are important to identify variables in taste research and suggest appropriate laboratory controls. Flowing the stimulus results in a magnitude estimation power function exponent under 1.0. Flow exponents are lower than sip exponents except when the stimulus range is large. Wider stimulus ranges produce lower sloped functions, for some stimuli. Magnitude production (the subject matches stimuli to numbers) yields steeper psychophysical functions for all stimuli tested. Changing flow rate has the same psychophysical effect as changing concentration; magnitude estimates as a function of flow rate are similar to magnitude estimates as a function of physical concentration. Neither the quality of stimulus compound (NaCl, sucrose, quinine, acid) nor the quality of response (e.g., sweet or total taste for sugar) has a clear effect on function slope.

1. PRESENTATION PROCEDURE. Sipped stimuli yield steeper functions than stimuli flowed over the tongue (Table 1). Published NaCl exponents show a relatively clean break between sip and flow exponents at an exponent value near 1.0. With sucrose, some sip experiments yield functions with slopes under 1.0. For both NaCl and sucrose, flowing the stimulus generally results in an exponent under 1.0. Flow exponents are lower than sip exponents except when the stimulus concentration range is relatively large, i.e. a high to low ratio of 100 or more when there is no difference between exponents (Table 1).

2. STIMULUS RANGE. Wider ranges produce lower sloped functions. Stimulus range and presentation procedure (sip, flow) have been systematically varied (Table II), replicated with NaCl, and extended to sucrose with different results (Table III). In both salt studies, stimulus range exerted a substantial effect, and the effect of presentation disappeared with high

TABLE I. FLOW & SIP MAGNITUDE ESTIMATION EXPONENTS WITH STIMULUS RANGE RATIOS (HI/LO) IN PARENTHESES

			FLOW		SIP	
SUCROSE:	MARKS & BARTOSHUK, 79[1]		.555	(11)	1.03	(16)
	BARTOSHUK & CLEVELAND, 77[2]		.75	(4)	1.67	(4)
	LAWLESS, 77[3]		.308	(31)	0.875	(31)
	MEISELMAN & BELL, 80		.82	(5)	.74	(5)
			.78	(100)	.78	(100)
	LAWLESS & SKINNER, 79[4]		.34	(6)	.69	(6)
NACL:	MEISELMAN, 71[5]		.78	(4)	1.35	(4)
	MEISELMAN & BELL, 79		1.05	(5)	1.41	(5)
			.78	(500)	.72	(500)
	MEISELMAN & BELL, 80		.97	(5)	1.09	(5)
			.76	(500)	.72	(500)
QUININE:	LAWLESS, 79[6]		.58	(100)		
	MEISELMAN, 71	W	.52	(16)		
					.54	(16)
		D	.31	(16)		
	LAWLESS, 77		.445	(1000)	.434	(1000)

TABLE II. STIMULUS RANGE & PRESENTATION PROCEDURE FOR NACL

RANGE	PREDICTED EXPONENTS SIP	PREDICTED EXPONENTS FLOW	ACTUAL EXPONENTS SIP	ACTUAL EXPONENTS FLOW
NARROW	HIGHEST	HIGHER?	1.41	1.05
WIDE	LOWER	LOWEST	0.72	0.78

TABLE III. STIMULUS RANGE & PROCEDURE FOR NACL & SUCROSE

RANGE	NACL SIP	NACL FLOW	SUCROSE SIP	SUCROSE FLOW
NARROW	1.09	.97	.74	.82
WIDE	.72	.76	.78	.78

stimulus range. Neither variable (range, presentation procedure) showed an effect for sucrose.

3. MAGNITUDE ESTIMATION VS. MAGNITUDE PRODUCTION. In magnitude estimation, the experimenter presents stimuli to which the subject assigns or matches numbers. In magnitude production, the roles are reversed; the experimenter presents numbers and the subject matches stimuli, ideally with continuously variable stimulus control. Magnitude production yields steeper sloped psychophysical functions than estimation. (Table IV)[7] Sipping

TABLE IV. MAGNITUDE PRODUCTION AND ESTIMATION

	NACL	QHCL	SUCROSE	HCL
Magnitude Estimation Exponent	0.91	0.85	0.93	0.99
Magnitude Production Exponent	2.09	1.28	2.93	0.70
Geometric Mean	1.37	1.04	1.62	0.83

of stimuli with a production procedure might yield even steeper functions. For NaCl and sucrose, the production exponent is 2-3 times the estimation exponent. If this ratio held for sipped stimuli, a slope as high as 4.0 might be obtained. Our procedures limit the range of observed exponents; although the variability in slopes is substantial with existing procedures, it might be much greater.

4. STIMULUS COMPOUND AND TASTE QUALITY. Are there differences in magnitude estimation functions for the compounds used to exemplify four taste qualities (sour, salty, bitter, sweet)? Meiselman, Bose and Nykvist[7] observed few differences among compounds for magnitude estimation, larger differences for production, and intermediate differences for the geometric mean (Table V). When these data are compared with research studying two or more compounds in the same experiment, there is no clear pattern. Cardello[8] and Moskowitz[9] found quinine and acid to have lower exponents than sucrose or NaCl but not different from each other, while Bartoshuk and Cleveland[2] found sucrose, quinine, and acid to have different exponents. Under restricted area filter paper stimulation, Collings[10] found no differences in exponent for the front of the tongue. No conclusion is possible at this time about general differences between compounds representing different taste qualities.

5. FLOW RATE. Magnitude estimations of taste intensity increase with the flow rate of the stimulus, for NaCl, Quinine HCL, sucrose, and HCl.[11] Meiselman and Bose suggested that flow rate

TABLE V. EXPONENTS FOR TASTE QUALITIES

	NACL	SUCROSE	QUININE	ACID
Cardello, 79 - sip	0.68	0.61	0.45	0.44
Moskowitz, 68 - sip	1.4	1.4	1.0	1.1
Bartoshuk & Cleveland, 79 - flow		0.75	0.60	0.49
Collings, 74 - paper	0.53	0.46	0.53	0.56

mimics physical concentration of the stimulus, by making more stimulus available per unit time. Slopes of psychophysical functions for NaCl flowed over the tongue range from 0.41 to 1.05, and when plotted over flow rates they range from 0.59 to 0.92. Flow rate is an important research tool, but it poses a serious problem of interpretation when permitted to vary because of insufficient stimulus control.

6. QUALITY RESPONSE. There is no clear effect of whether one judges "total taste intensity" or "quality intensity". For sweetness the same range of exponents exists for judgments of sweet (.31-1.80) and total taste (.46-1.67). This should be examined for other tastes as well, although published descriptions of procedure do not always permit such an analysis.

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